

Design-based Estimates of Abundance from ROV Data

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Recap of Previous Sections

- Density data: Decreasing to the south. Higher at the Farallon Islands.
- Length data: Recruitment south of $40^{\circ} 10'$ N. Lat, larger fish at the Farallon Islands and to the north.
- Habitat Area Estimates: CMECS (State and Federal Waters) and CSMP (State Waters).
- Fish lengths converted to weights using length/weight relationships from the assessment.

Expansion Frame

- Latitude: Oregon/California to Point Sur
- Depth: 20 m to 90 m
- Density: All bottom types observed by the ROV over transects
- Conservative Expansions
- No depth stratifications since no distinct breaks

Depth (m)	Fish	Density (Fish/Square Meter)	Transects Sampled
0-10	0	0	0
10-20	2	0.000196724	10
20-30	46	0.000338732	153
30-40	164	0.001122868	155
40-50	332	0.002180902	167
50-60	382	0.002450196	173
60-70	314	0.002834064	131
70-80	74	0.001417482	55
80-90	43	0.000618206	66
90-100	3	0.000161173	19
100-110	0	0	6
All Depths	1360	0.001613925	935

Latitude (Degrees)	Fish	Density (Fish/Square Meter)	Transects Sampled
41-42	478	0.003689607	155
40-41	149	0.002456499	59
39-40	158	0.002166626	81
38-39	260	0.001799346	177
37-38	290	0.001528266	178
36-37	25	0.000127114	206
35-36	0	0	79
34-35	0	0	0
Oregon Border to Point Conception	1360	0.001613925	935

Stratification Schemes

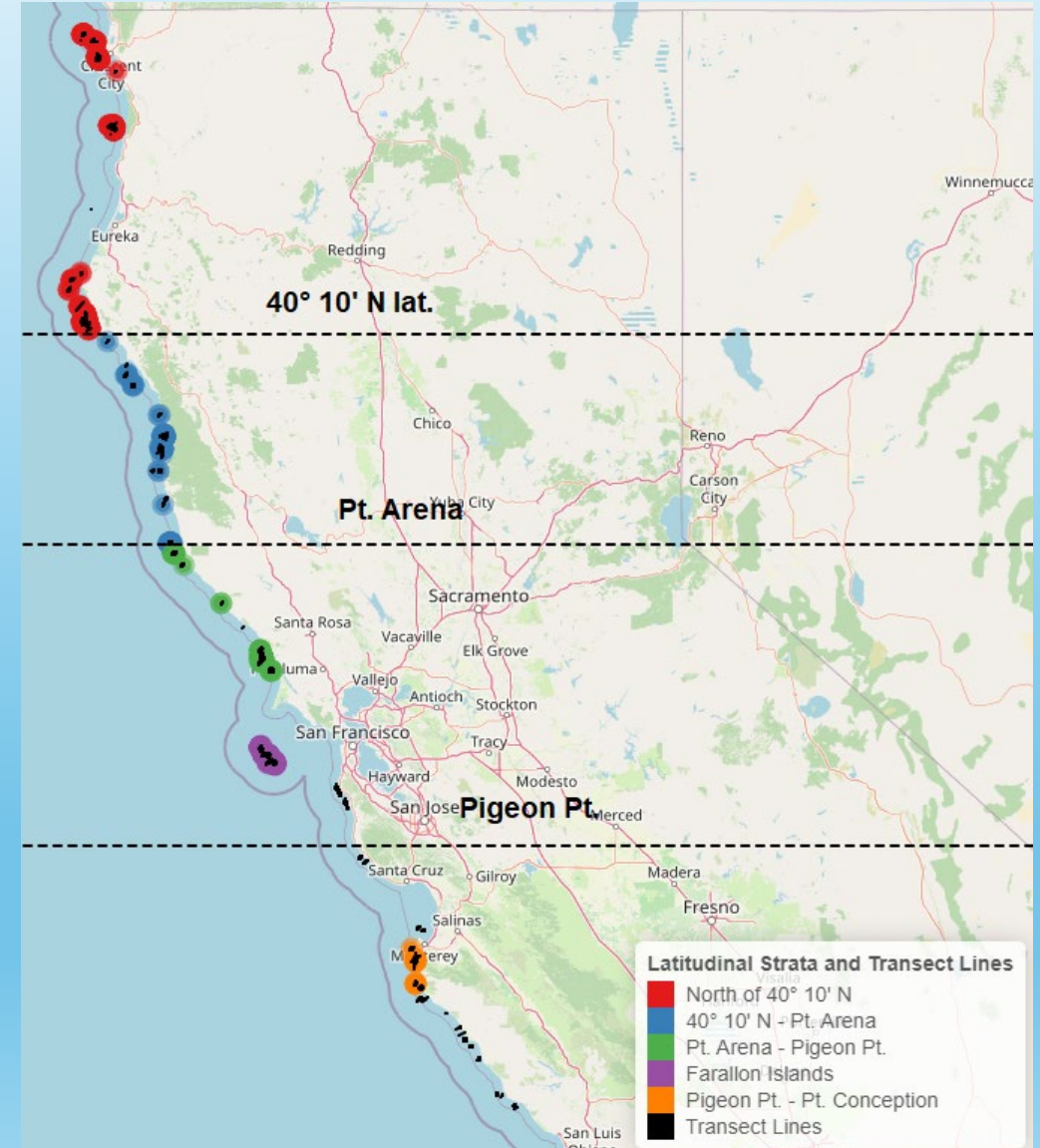
1.) Oregon/California Border to Point Sur

2.) Oregon California to 40 deg 10 min N. Lat, 40 deg 10 min N. Lat to Point Arena, Farallon Islands, Point Arena to Pigeon Point, Pigeon Point to Point Sur

3.) Oregon California to Point Arena, Point Arena to Point Sur, Farallon Islands

4.) Oregon California to 40 deg 10 min N. Lat, 40 deg 10 min N. Lat to Point Arena, Point Arena to Point Sur

5.) Oregon California to Point Arena, Point Arena to Point Sur



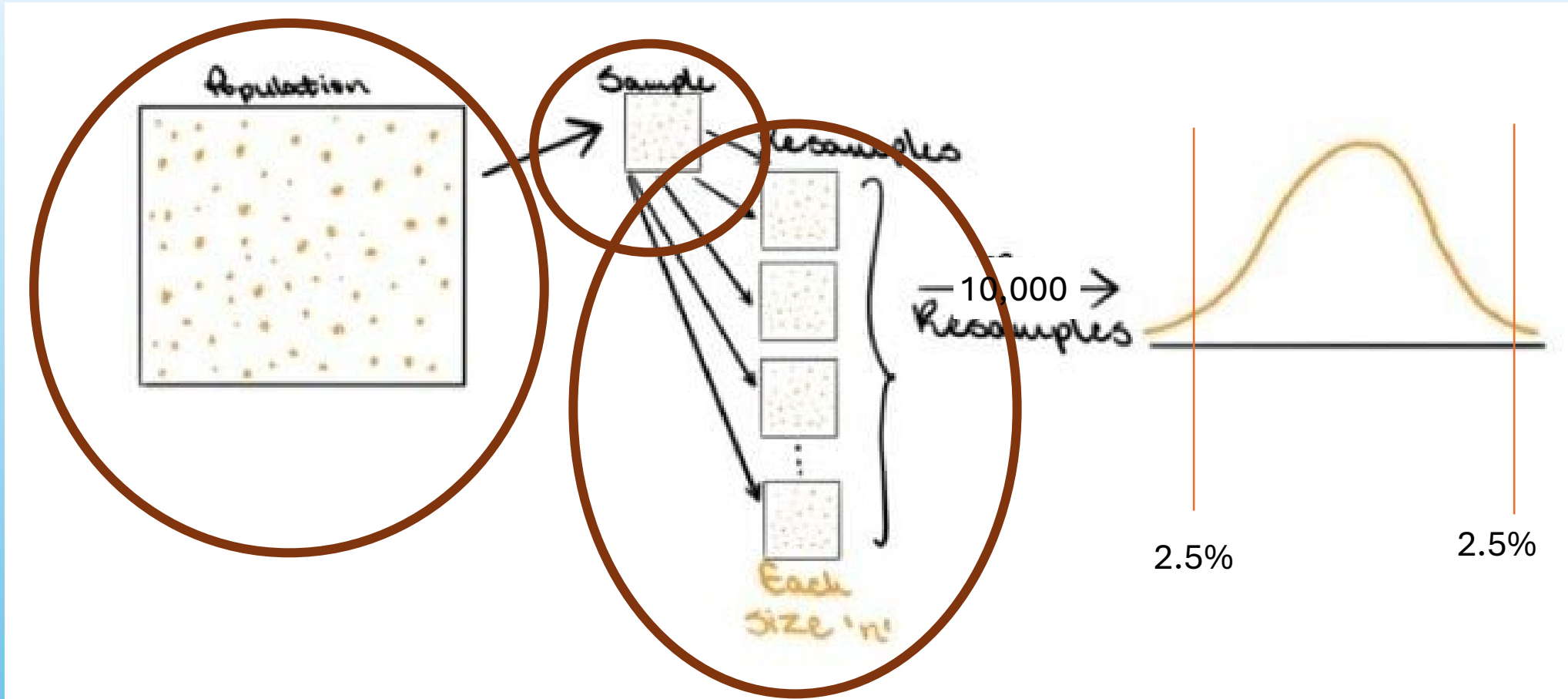
Calculations

- Numbers of fish = Density x Area
- Biomass = Density x Area x Average Weight
- Bootstrapped estimates of the mean and confidence intervals

Stratification Scheme	Area	Super Year	Mean Density Outside MPAs	Mean Density Inside MPAs	Meters Squared per Square Mile	Square Miles Outside MPAs	Square Miles Inside MPAs	Mean Fish Outside MPAs	Mean Fish Inside MPAs	Total Fish	
4	North of 40° 10' N. Lat	2015	0.0027009	0.0025481	2589988	45.1	10.9	315004	71687	386691	
		2020	0.0037613	0.0047913	2589988	45.1	10.9	440289	134934	575223	
	40° 10' to Point Arena	2015	0.0013565	0.0016094	2589988	18.0	2.6	63455	11065	74520	
		2020	0.0023588	0.0051163	2589988	18.0	2.6	109133	35110	144243	
	Point Arena to Point Sur	2015	0.0009618	0.0006459	2589988	128.4	25.1	321153	41917	363071	
		2020	0.0009087	0.0016892	2589988	128.4	25.1	302573	109701	412274	
	Total		2015	0.001673	0.001601		191.5	38.6	699612	124670	824282
			2020	0.002343	0.003866		191.5	38.6	851995	279745	1131740
	5	North of Point Arena	2015	0.0023144	0.0022352	2589988	63.0	13.5	377990	78386	456376
			2020	0.0033636	0.0049137	2589988	63.0	13.5	549955	172145	722100
Point Arena to Point Sur		2015	0.0009618	0.0006459	2589988	99.2	21.2	247641	35491	283132	
		2020	0.0009087	0.0016892	2589988	99.2	21.2	233089	92881	325970	
Total			2015	0.001638	0.001441		162.2	34.8	625631	113877	739508
			2020	0.002136	0.003301		162.2	34.8	783044	265026	1048070

Stratification Scheme	Area	Super Year	Total Fish	Mean Weight Outside MPAs	Mean Weight Inside MPAs	Mean Bootstrap Biomass Outside MPAs (kg)	Mean Bootstrap Biomass Inside MPAs (kg)	kg per metric ton	Mean Bootstrap Biomass Outside MPAs (mt)	Mean Bootstrap Biomass Inside MPAs (mt)	Total Bootstrap Biomass	
4	North of 40° 10' N. Lat	2015	386691	1.33	1.17	418840	84135	1000	419	84	503	
		2020	575223	1.13	1.01	497580	135634	1000	498	136	633	
	40° 10' to Point Arena	2015	74520	0.89	0.65	56589	7151	1000	57	7	64	
		2020	144243	0.61	0.56	66542	19594	1000	67	20	86	
	Point Arena to Point Sur	2015	363071	0.20	0.44	62591	18256	1000	63	18	81	
		2020	412274	0.60	0.53	181036	58402	1000	181	58	239	
	Total		2015	824282	0.81	0.75	538020	109543	1000	538	110	648
			2020	1131740	0.78	0.70	745157	213629	1000	745	214	959
	5	North of Point Arena	2015	456376	1.21	0.93	457075	72807	1000	457	73	530
			2020	722100	0.99	0.82	545144	141750	1000	545	142	687
Point Arena to Point Sur		2015	283132	0.20	0.44	48680	15511	1000	49	16	64	
		2020	325970	0.60	0.53	139600	49450	1000	140	49	189	
Total			2015	739508	0.70	0.68	505756	88319	1000	506	88	594
			2020	1048070	0.79	0.68	684744	191200	1000	685	191	876

Bootstrapping Illustration



Fish Count Confidence Intervals

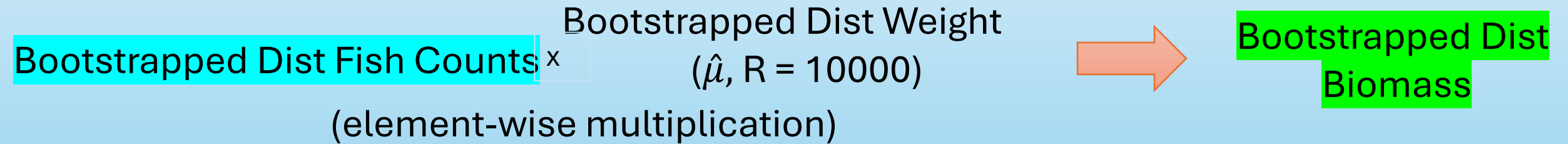
BoostrappedDist Density
($\hat{\mu}$, R = 10000) x Surface Area  Bootstrapped Dist Fish Counts

Percentile Method

Fish Count Lower CI = Quantile(Bootstrapped Dist Fish Counts, 0.025)

Fish Count Upper CI = Quantile(Bootstrapped Dist Fish Counts, 0.975)

Biomass Confidence Intervals



Percentile Method

Biomass Lower CI = Quantile(Bootstrapped Dist Biomass, 0.025)

Biomass Upper CI = Quantile(Bootstrapped Dist Biomass, 0.975)

Area A

Bootstrapped Dist

Biomass

+

Area B

Bootstrapped Dist

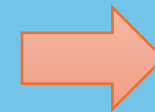
Biomass



Area A & B

Bootstrapped Dist

Biomass



Percentile
Method

Stratification Scheme 1: OR/CA Border to Point Sur

- Number of fish increased, while metric tonnage decreased
- Recruitment south of 40 deg 10 min N. Lat in 2020 causing decline when not stratified due to lower average weight

Stratification Scheme	Area	Super Year	Total Fish	Mean Weight Outside MPAs	Mean Weight Inside MPAs	Mean Bootstrap Biomass Outside MPAs (kg)	Mean Bootstrap Biomass Inside MPAs (kg)	kg per metric ton	Mean Bootstrap Biomass Outside MPAs (mt)	Mean Bootstrap Biomass Inside MPAs (mt)	Total Bootstrap Biomass	
1	Oregon Border to Point Sur	2015	969143	1.17	0.84	971495	117486	1000	971	117	1089	
		2020	1118179	0.80	0.68	666131	195686	1000	666	196	862	
2	North of 40° 10' N. Lat	2015	386661	1.33	1.17	419082	84296	1000	419	84	503	
		2020	573473	1.13	1.01	496027	135612	1000	496	136	632	
	40° 10' to Point Arena	2015	74069	0.89	0.65	56139	7143	1000	56	7	63	
		2020	144779	0.61	0.56	66791	19585	1000	67	20	86	
	Farallon Islands	2015	326102	0.675	0.7066	200158	20868	1000	200	21	221	
		2020	323100	0.68	0.71	187539	31901	1000	188	32	219	
	Point Arena to Pigeon Point	2015	123892	0.20	0.46	21767	5566	1000	22	6	27	
		2020	224690	0.33	0.17	51508	11916	1000	52	12	63	
	Pigeon Point to Point Sur	2015	4283	0.77	0.36	0	1564	1000	0	2	2	
		2020	10512	0.77	0.80	6217	1955	1000	6	2	8	
Total		2015	588905	0.84	0.70	697147	119437	1000	697	119	817	
		2020	1276554	0.72	0.65	808083	200969	1000	808	201	1009	
3	North of Point Arena	2015	457060	1.21	0.93	458023	73085	1000	458	73	531	
		2020	721037	0.99	0.82	543073	142236	1000	543	142	685	
	Farallon Islands	2015	0	0.68	0.71	199091	20829	1000	199	21	220	
		2020	324464	0.68	0.71	188631	31826	1000	189	32	220	
	Point Arena to Point Sur	2015	96926	0.20	0.44	15708	7136	1000	16	7	23	
		2020	182430	0.43	0.22	51904	13276	1000	52	13	65	
	Total		2015	553986	0.69	0.69	672822	101050	1000	673	101	774
			2020	1227931	0.70	0.58	783607	187338	1000	784	187	971

Stratification Schemes 2 and 3

- Missing 2015 average weight at the Farallon Islands, proxy 2020
- Missing density south of Point Sur outside MPAs in 2015, used inside MPA as proxy

Stratification Scheme	Area	Super Year	Total Fish	Mean Weight Outside MPAs	Mean Weight Inside MPAs	Mean Bootstrap Biomass Outside MPAs (kg)	Mean Bootstrap Biomass Inside MPAs (kg)	kg per metric ton	Mean Bootstrap Biomass Outside MPAs (mt)	Mean Bootstrap Biomass Inside MPAs (mt)	Total Bootstrap Biomass
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		2020	573473	1.13	1.01	496027	135612	1000	496	136	632
	40° 10' to Point Arena	2015	74069	0.89	0.65	56139	7143	1000	56	7	63
		2020	144779	0.61	0.56	66791	19585	1000	67	20	86
	Farallon Islands	2015	326102	0.675	0.7066	200158	20868	1000	200	21	221
		2020	323100	0.68	0.71	187539	31901	1000	188	32	219
	Point Arena to Pigeon Point	2015	123892	0.20	0.46	21767	5566	1000	22	6	27
		2020	224690	0.33	0.17	51508	11916	1000	52	12	63
	Pigeon Point to Point Sur	2015	4283	0.77	0.36	0	1564	1000	0	2	2
		2020	10512	0.77	0.80	6217	1955	1000	6	2	8
Total	2015	588905	0.84	0.70	697147	119437	1000	697	119	817	
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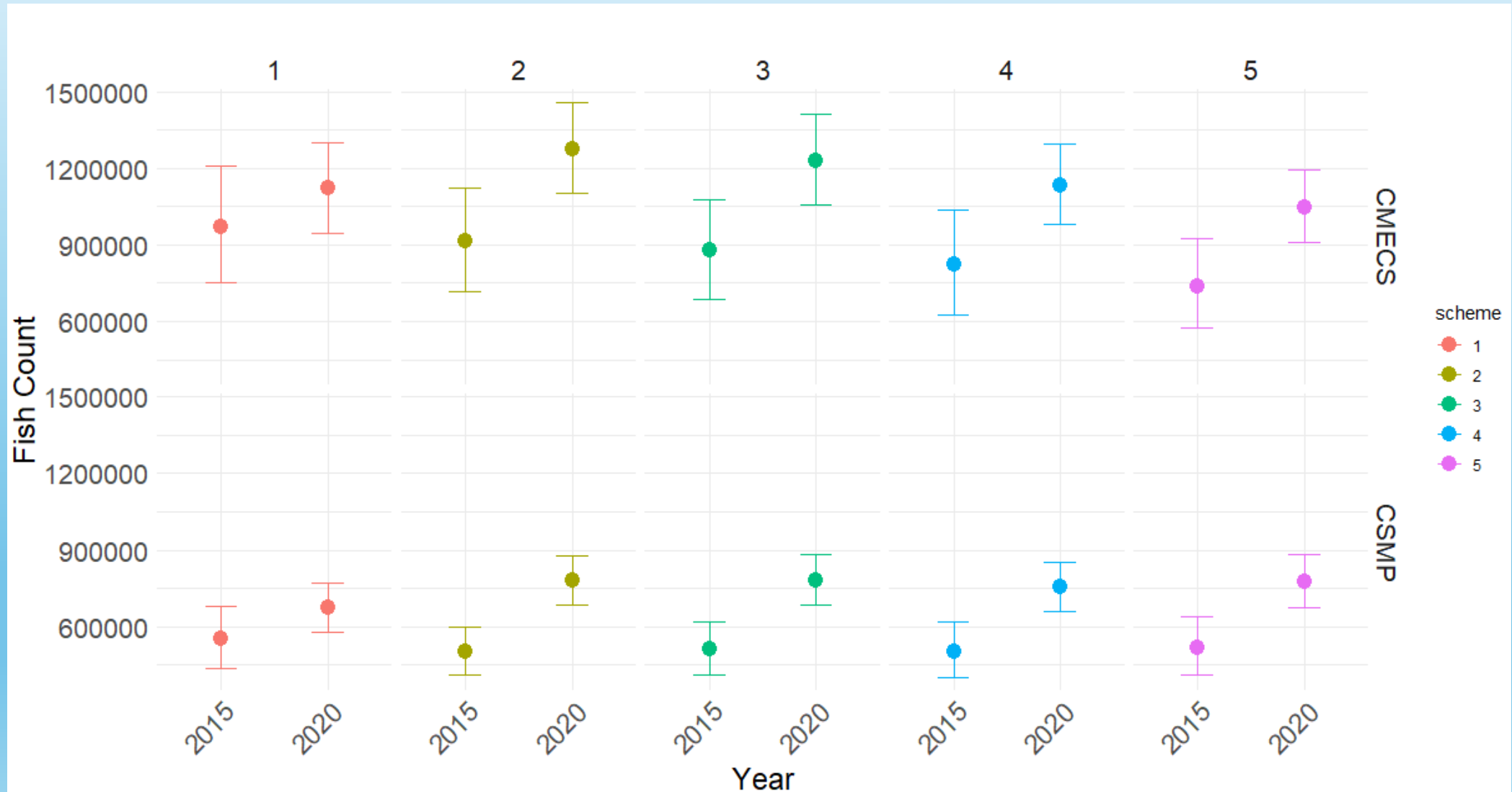
Stratification Schemes 4 and 5

- Combined area south of Pigeon Point and Farallon Islands with the rest of the area south of Point Arena
- Lower estimates than Schemes 1, 2 and 3

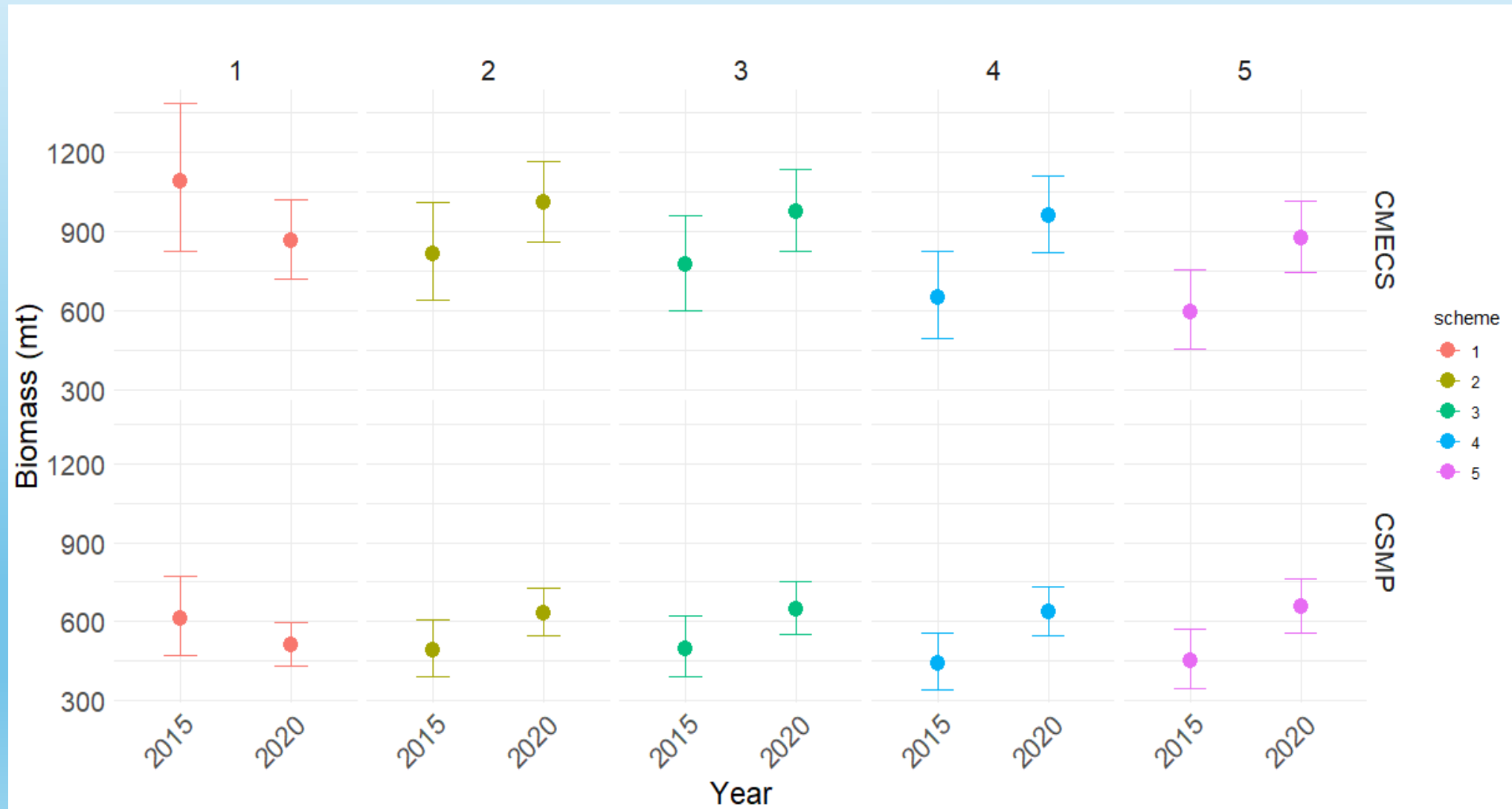
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	Total		2015	739508	0.70	0.68	505756	88319	1000	506	88	594
			2020	1048070	0.79	0.68	684744	191200	1000	685	191	876



Confidence Intervals: Numbers of Fish



Confidence Intervals: Biomass



Trends Observed

MPA vs. Open

- Increasing in both, but greater in MPAs
- Densities vary due to depth or latitude, but typically higher in MPAs.
- Site selection or accumulation of biomass due to closure

Over Time

- Increasing trend in total and inside vs. outside
- Numbers increase in all scenarios; biomass decreases in scenario 1 due to smaller fish in the south



Scale Comparison to Assessments

- Potential Causes for Discrepancy
 - Unreported encounters, ID, Uncommon, Undesirable
 - Sampling frame for MPA and Reference sites – need more sampling
 - Seafloor Habitat Area Resolution – need higher resolution in Fed waters.

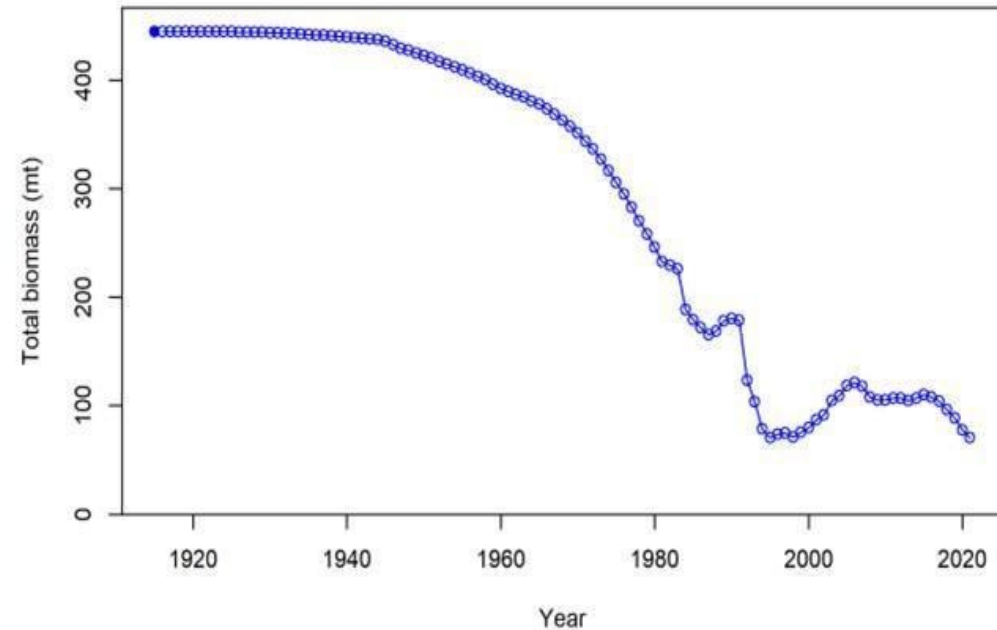


Figure 23: Estimated time series of total biomass.

Incorporation in Assessments

- Awareness informing interpretation of sensitivities related to scale
- Relative indices of abundance
- Adjustments to scale through catchability
- Length composition data

Year	Total Biomass (mt)	Spawning Output	Total Biomass 3+ (mt)	Fraction Un-fished	Age-0 Recruits	Total Mortality (mt)	1-SPR	Exploitation Rate
1993	103.81	9.92	101.23	0.18	26.07	40.67	0.96	0.40
1994	78.69	7.12	76.20	0.13	42.59	23.90	0.93	0.31
1995	70.28	5.81	68.24	0.11	18.48	12.66	0.89	0.19
1996	73.59	5.85	70.74	0.11	70.50	15.56	0.91	0.22
1997	75.08	5.88	73.19	0.11	13.02	22.98	0.94	0.31
1998	71.18	5.29	66.93	0.10	13.66	14.98	0.91	0.22
1999	75.16	5.56	74.02	0.10	92.17	13.81	0.90	0.19
2000	80.00	6.02	78.15	0.11	10.68	13.31	0.88	0.17
2001	86.73	6.82	81.26	0.12	9.57	16.10	0.89	0.20
2002	91.47	7.39	90.73	0.13	8.86	5.96	0.70	0.07
2003	104.93	8.76	104.25	0.16	10.45	13.92	0.84	0.13
2004	108.84	9.75	108.18	0.18	14.50	5.64	0.60	0.05
2005	118.38	11.76	117.57	0.21	17.11	10.59	0.73	0.09
2006	121.11	12.85	120.05	0.23	10.06	14.55	0.79	0.12
2007	117.91	12.90	116.79	0.23	7.71	19.32	0.85	0.17
2008	108.25	11.93	107.56	0.22	7.25	11.05	0.75	0.10
2009	105.22	11.66	104.67	0.21	8.16	6.88	0.64	0.07
2010	104.97	11.80	104.42	0.21	12.50	3.56	0.46	0.03
2011	107.13	12.27	106.44	0.22	28.47	5.45	0.57	0.05
2012	106.95	12.39	105.87	0.22	15.17	7.99	0.68	0.08
2013	104.56	12.04	102.72	0.22	9.06	3.57	0.46	0.03
2014	106.98	12.13	105.99	0.22	6.86	2.97	0.41	0.03
2015	110.22	12.30	109.61	0.22	6.87	8.55	0.70	0.08
2016	107.80	12.00	107.30	0.22	9.00	9.46	0.73	0.09
2017	103.96	11.74	103.43	0.21	11.69	12.52	0.79	0.12
2018	96.59	11.06	95.90	0.20	17.10	12.84	0.81	0.13
2019	88.55	10.19	87.64	0.18	16.70	16.02	0.87	0.18
2020	77.52	8.78	76.30	0.16	15.78	12.34	0.85	0.16
2021	70.60	7.75	69.42	0.14	14.99	13.50	0.88	0.19
2022	63.18	6.61	62.06	0.12	13.97	13.50	0.90	0.22
2023	56.39	5.60	55.34	0.10	12.89	0.03	0.01	0.00
2024	63.27	6.29	62.28	0.11	13.65	0.34	0.12	0.01
2025	70.34	7.10	69.40	0.13	14.44	0.68	0.19	0.01
2026	77.37	7.98	76.38	0.14	15.18	1.03	0.25	0.01
2027	84.21	8.86	83.17	0.16	15.84	1.37	0.29	0.02
2028	90.82	9.70	89.72	0.18	16.40	1.69	0.31	0.02
2029	97.20	10.48	96.06	0.19	16.87	1.97	0.33	0.02
2030	103.37	11.23	102.19	0.20	17.28	2.23	0.35	0.02
2031	109.38	11.95	108.17	0.22	17.64	2.48	0.36	0.02

Stand Alone Application

- F_{msy} Proxy * Biomass to provide OFL with Category 3 buffer to ABC
- Regional Management
- None Observed South of Point Sur

